

Parasitic Copepods on Three Species of Centrarchids from Gull Lake, Michigan

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ABSTRACT: The gills and buccal cavities of 101 rock bass, *Ambloplites rupestris*, 27 largemouth bass, *Micropterus salmoides*, 25 smallmouth bass, *M. dolomieu*, 63 bluegill, *Lepomis macrochirus*, 2 pumpkinseed, *L. gibbosus*, and 1 warmouth, *Chaenobryttus gulosus* (Centrarchidae), were examined for parasitic copepods from Gull Lake, Michigan, in September–October 1990 and June 1993. *Ergasilus centrarchidarum* (Copepoda: Ergasilidae), the most common species found, and *Achtheres pimelodi* (Copepoda: Lernaepodidae) were recovered from rock bass, smallmouth bass, and largemouth bass. *Ergasilus* spp. infected the gill filaments, whereas *A. pimelodi* attached primarily to the gill arches, rakers, and buccal cavity. The distribution of *E. centrarchidarum* and *A. pimelodi* on the gills is discussed. *Ergasilus centrarchidarum* and *A. pimelodi* are believed to have been introduced into Gull Lake around 1974.

KEY WORDS: *Ergasilus centrarchidarum*, *Ergasilus megaceros*, *Achtheres pimelodi*, parasitic copepods, Centrarchidae, Gull Lake, Michigan.

Esch (1971), Esch and Huffines (1973), and Esch et al. (1975) have reported on many aspects of helminths infecting several species of centrarchids in Gull Lake, Michigan. Parasitic copepods were never seen on centrarchids by these authors in 1967, 1968, 1969, 1972, and 1973 (G. W. Esch and J. R. Coggins, pers. comm.). Parasitic copepods were first seen on rock bass in Gull Lake in 1975 (H. Blankenspoor and J. Johnson, pers. comm.). During a parasitological study of rock bass from Gull Lake in 1990, 3 copepod species (*Ergasilus centrarchidarum* Wright, 1882, *Ergasilus megaceros* Wilson, 1916, and *Achtheres pimelodi* Kroyer, 1863) were found on the gills of rock bass. This study provides information on host specificity, abundance related to sex and length of the hosts, and distribution of *E. centrarchidarum*, *E. megaceros*, and *A. pimelodi* infecting rock bass, largemouth bass, and smallmouth bass in Gull Lake, Michigan.

Materials and Methods

Centrarchids were collected in September–October 1990 and June 1993 from Gull Lake, Barry and Kalamazoo counties, southwestern lower Michigan. A description and characterization of Gull Lake can be found in Dexter (1991). Fishing gear consisted of experimental gill nets (38 m long × 1.8 m deep, with 5 equal panels of 3.8, 5.1, 6.4, 7.6, and 10.2 cm stretch mesh) and trap nets (pot with 3.8 cm stretch mesh, with a 22.9 m lead, 1.8 m deep). Fish were removed from the nets, preserved on ice, packaged, and frozen.

The buccal cavity, gill filaments, arches, and rakers

of 219 centrarchids (101 rock bass, 27 largemouth bass, 25 smallmouth bass, 63 bluegill, 2 pumpkinseed, and 1 warmouth) were examined for copepods. Total length (mm) and sex of each fish were recorded at necropsy. Gills were numbered 1–4, with gill 1 being outermost (anteriorly attached) and gill 4 being innermost (posteriorly attached). Separate gills were placed in labeled petri dishes and examined. The long gill rakers of rock bass were numbered 1–4 anterioposteriorly. *Ergasilus centrarchidarum* and *E. megaceros* were identified using information in Roberts (1970). *Achtheres pimelodi* was identified using information in and following the synonymy of Kabata (1988). The position of copepods on the gill was noted; they were then removed, counted, and preserved in 70% alcohol. Voucher specimens have been deposited in the U.S. National Parasite Collection, Beltsville, Maryland 20705: *Ergasilus centrarchidarum* (83637), *Ergasilus megaceros* (83638), and *Achtheres pimelodi* (83639).

Twenty-five gravid *E. centrarchidarum* were taken from each host species collected in June 1993. The length of the cephalothorax of each copepod was measured in micrometers under a microscope coverslip. Eggs from the egg sacs were counted to provide an indication of reproductive potential of the species at this time. The ratio of egg number to cephalothorax length was calculated for each copepod from each host species.

Prevalence is the percentage of fish infected, and mean intensity is the mean number of copepods per infected fish. Chi-square tests compared prevalence in relation to host sex, between fish species and collection times. The Kruskal-Wallis test was used to compare intensity in relation to host sex, host species, collection times, gills on the left and right sides of each fish species, and between the gills on each side. Correlation coefficients were calculated to investigate the relationship of copepod intensity and host length. All tests were performed at a significance level of $P < 0.05$.

Table 1. Prevalence and mean intensity of *Ergasilus centrarchidarum*, *Ergasilus megaceros*, and *Achtheres pimelodi* from three species of centrarchids from Gull Lake.

Copepod species	Fish species*	Date collected	Mean fish total length ± SD (range, mm)	No. exam- ined	Mean intensity ± SD (maximum)	
					No. inf. (%)	
<i>Ergasilus centrarchidarum</i>	RB	Sept./Oct. 1990	163 ± 38 (90–265)	51	51 (100)	30.1 ± 18.7 (74)
	RB	June 1993	172 ± 35 (110–278)	50	49 (98)	28.7 ± 23.1 (127)
	LMB	Sept./Oct. 1990	249 ± 62 (121–304)	7	7 (100)	16.7 ± 13.8 (40)
	LMB	June 1993	260 ± 59 (183–431)	20	20 (100)	13.9 ± 10.9 (45)
	SMB	Sept./Oct. 1990	102 ± 49 (71–245)	18	5 (28)	40.0 ± 53.6 (110)
	SMB	June 1993	265 ± 85 (175–380)	7	7 (100)	55.7 ± 30.4 (96)
<i>Ergasilus megaceros</i>	RB	Sept./Oct. 1990	163 ± 38 (90–265)	51	36 (71)	12.5 ± 19.7 (86)
	RB	June 1993	172 ± 35 (110–278)	50	4 (8)	2.5 ± 1.7 (4)
	LMB	Sept./Oct. 1990	249 ± 62 (121–304)	7	3 (43)	5.7 ± 4.0 (8)
<i>Achtheres pimelodi</i>	RB	Sept./Oct. 1990	163 ± 38 (90–265)	51	22 (43)	1.7 ± 1.2 (4)
	RB	June 1993	172 ± 35 (110–278)	50	39 (78)	2.3 ± 1.3 (5)
	LMB	Sept./Oct. 1990	249 ± 62 (121–304)	7	2 (29)	1.5 ± 0.7 (2)
	LMB	June 1993	260 ± 59 (183–431)	20	12 (60)	3.3 ± 2.2 (8)
	SMB	Sept./Oct. 1990	102 ± 49 (71–245)	18	1 (6)	2
	SMB	June 1993	265 ± 85 (175–380)	7	5 (71)	4.8 ± 2.8 (9)

* Abbreviations: RB = rock bass (*Ambloplites rupestris*), LMB = largemouth bass (*Micropterus salmoides*), SMB = smallmouth bass (*Micropterus dolomieu*).

Results

Ergasilus centrarchidarum occurred on the gill filaments of rock bass, smallmouth bass, and largemouth bass in September–October 1990 and June 1993 (Table 1). The prevalence and mean intensity of *E. centrarchidarum* on each species were high and similar between dates except for smallmouth bass. Fifteen of the 18 smallmouth bass examined in 1990 were 95 mm in length or less, and only 2 were infected with *E. centrarchidarum*. The mean intensity of *E. centrarchidarum* was 65.7 ± 57.3 on the remaining 3 smallmouth bass. These bass had a mean length \pm SD of $191 \text{ mm} \pm 74.5$ (range 106–245). There were no significant correlations between intensities of *E. centrarchidarum* and host species length. No significant differences were found in the mean

intensities of *E. centrarchidarum* on gills between the left and right sides of each fish species in 1990 and 1993. There were no significant differences in the distribution of *E. centrarchidarum* between gills on the left and right sides for each host species. However, there was a trend of decreasing intensity of *E. centrarchidarum* on smallmouth bass from gills 1 through 4.

Three percent or less of the female *E. centrarchidarum* on each host species in 1990 had egg sacs. In 1993, 78% or more of the females on each host species had egg sacs (Table 2). The highest percentage of *E. centrarchidarum* with egg sacs occurred on largemouth bass. The cephalothorax length of females with egg sacs and egg number on each host species are shown in Table 3. Female *E. centrarchidarum* infecting rock bass had the largest mean cephalothorax length, while

Table 2. Numbers (percentages) of *Ergasilus centrarchidarum* and *Achtheres pimelodi* with and without egg sacs on *Ambloplites rupestris*, *Micropterus salmoides*, and *Micropterus dolomieu* from Gull Lake, June 1993.

Fish species	<i>E. centrarchidarum</i>			<i>A. pimelodi</i>		
	Total numbers	With egg sacs	Without egg sacs	Total numbers	With egg sacs	Without egg sacs
<i>Ambloplites rupestris</i>	1,404	1,097 (78)	307 (22)	90*	37 (41)	51 (57)
<i>Micropterus salmoides</i>	279	262 (94)	17 (6)	39	15 (38)	24 (62)
<i>Micropterus dolomieu</i>	390	358 (92)	32 (8)	24†	4 (17)	19 (79)

* Two males included.

† One male included.

Table 3. Cephalothorax length (micrometers) and egg number of 25 *Ergasilus centrarchidarum* from each of 3 host species from Gull Lake, June 1993.

Host	Mean cephalothorax length \pm SD (range)	Mean number of eggs \pm SD (range)	Ratio of mean egg number/mean cephalothorax length (range)
<i>Ambloplites rupestris</i>	344.7 \pm 15.6 (318.4–378.8)	189.0 \pm 42.6 (119–270)	0.5484 \pm 0.1189 (0.3430–0.7700)
<i>Micropterus salmoides</i>	329.3 \pm 16.9 (298.2–354.6)	155.0 \pm 34.4 (91–215)	0.4724 \pm 0.0994 (0.2660–0.6210)
<i>Micropterus dolomieu</i>	335.6 \pm 20.3 (294.2–386.9)	207.2 \pm 35.5 (146–254)	0.6186 \pm 0.1070 (0.4070–0.8100)

individuals from smallmouth bass had the largest mean egg number and mean egg number-to-mean cephalothorax length ratio.

Ergasilus megaceros occurred on the gill filaments of rock bass and largemouth bass with highest infection values on the rock bass in 1990 (Table 1). Less than 1% of the females on hosts in 1990 and only 1 individual (10%) on rock bass in 1993 had egg sacs.

Achtheres pimelodi infected rock bass, largemouth bass, and smallmouth bass in 1990 and 1993 (Table 1). Infection values were highest on each host species in 1993. Correlation coefficients between the intensity of *A. pimelodi* and host species length on each date were not significant. In 1990, 21% of the *A. pimelodi* on rock bass had egg sacs. The numbers of female *A. pimelodi* with egg sacs on largemouth and smallmouth bass were not kept in 1990. The percentage of *A. pimelodi* with egg sacs was highest on rock bass in 1993 (Table 2). The prevalences and mean intensities of *A. pimelodi*, *E. centrarchidarum*, and *E. megaceros* were not significantly different between host sexes.

Achtheres pimelodi was attached to the gill arch,

raker, filament, and buccal cavity of the hosts (Table 4). The number of *A. pimelodi* was highest on the arch and rakers of gill 1 and decreased through gill 4 on each host species. *Achtheres pimelodi* was commonly attached to the buccal cavity of largemouth bass. The total number of *A. pimelodi* on long rakers 1, 2, 3, and 4 for all the gills of rock bass were 30, 10, 6, and 4, respectively. Two male *A. pimelodi* were attached to 1 female on a rock bass and 1 male was attached to 1 female infecting a smallmouth bass.

Sixty-three bluegill (\bar{x} length \pm SD = 146 mm \pm 37.4, range 85–230 mm), 2 pumpkinseed (\bar{x} length = 185 mm), and 1 warmouth (length = 190 mm) examined in June 1993 were negative for copepods.

Discussion

Fish host species for *Ergasilus centrarchidarum*, *E. megaceros*, and *Achtheres pimelodi* are similar but vary by location. Tedla and Fernando (1969) found *E. centrarchidarum* infecting rock bass and smallmouth bass but not pumpkinseed from Lake Ontario. Cloutman and Becker (1977) reported that 151 bluegill from Arkansas were negative for *E. centrarchidarum* while largemouth bass and spotted bass, *Micropterus punctulatus*, were infected. Burris and Miller (1972) found *E. centrarchidarum* on 9 species of centrarchids including bluegill from several North Carolina locations. Hanek and Fernando (1978a, b) discussed the host–parasite relationships of *E. centrarchidarum* infecting rock bass and pumpkinseed from Lake Ontario. Miller et al. (1982) found *E. centrarchidarum* on largemouth bass, black crappie (*Pomoxis nigromaculatus*), white crappie (*P. annularis*), and white catfish (*Ictalurus catus*), from North Carolina; while 287 bluegill, 124 green sunfish (*Lepomis cyanellus*), and 23 pumpkinseed were negative. Davis and

Table 4. Distribution of *Achtheres pimelodi* on the arches and rakers of different gills and filaments and in the buccal cavity of 3 species of centrarchids from Gull Lake, June 1993.

Site	<i>Ambloplites rupestris</i>	<i>Micropterus salmoides</i>	<i>Micropterus dolomieu</i>
Arch or raker of gill			
1	66	9	13
2	13	8	2
3	5	7	2
4	3	1	0
Gill filament	1	0	1
Buccal cavity	0	14	5

Miller (1989) found *E. centrarchidarum* on bluegill, pumpkinseed, and white crappie in North Carolina. The absence of *E. centrarchidarum* on bluegill from Gull Lake in 1993 is noteworthy because bluegill, rock bass, and bass were caught in the same nets together on the same dates.

Tedla and Fernando (1969) considered the rock bass to be the preferred host of *E. centrarchidarum* in Lake Ontario based on cephalothorax length and egg number. Using the same characteristics, *E. centrarchidarum* from rock bass in Gull Lake had the largest mean cephalothorax length, while females from smallmouth bass in June 1993 had the largest mean egg number and mean egg number-to-cephalothorax length ratio. The mean intensities of *E. centrarchidarum* also were highest on smallmouth bass. Therefore, rock bass and smallmouth bass are preferred hosts for *E. centrarchidarum* in Gull Lake. Largemouth bass are also appropriate hosts for *E. centrarchidarum* based on prevalence and mean intensity. The results of this study and of Tedla and Fernando (1969) suggest that *E. centrarchidarum* has seasonal preferred hosts or its preferred hosts vary between locations.

The mean cephalothorax lengths and egg numbers of *E. centrarchidarum* in the present study differ from values reported by Tedla and Fernando (1969) and for egg number by Cloutman and Becker (1977). Female *E. centrarchidarum* in our study were collected in June, whereas Tedla and Fernando (1969) collected specimens in August, which may explain why their specimens attained a larger mean size than ours. Egg production and number of *E. centrarchidarum* may depend on an optimum water temperature range (Cloutman and Becker, 1977). Therefore, egg number may vary among studies because optimum water temperature ranges occur in different months at different locations. More *E. centrarchidarum* with egg sacs were found on hosts in June 1993 than in September–October 1990 in Gull Lake. Similarly, Cloutman and Becker (1977) found that *E. centrarchidarum* laid eggs in June–September and females did not have egg sacs during the cold months.

Ergasilus megaceros has been found in the nasal fossae and on the gill filaments of ictalurids, catostomids, and cyprinids, primarily occurring east of the Mississippi River. Fish from these groups were not examined from Gull Lake. Although *E. megaceros* infected rock bass and largemouth bass from Gull Lake, few females had egg sacs indicating that centrarchids may not

be preferred hosts. Rock bass and largemouth bass are new host records, and Michigan is a new state record for *E. megaceros*. This species, to our knowledge, has not been reported from Canada.

Achtheres pimelodi has been reported from the gills of many fish species: largemouth bass and spotted bass by Becker et al. (1966) and Cloutman and Becker (1977) in Arkansas, rock bass and pumpkinseed by Hanek and Fernando (1978a) in Ontario, and bluegill by Davis and Miller (1989) and largemouth bass by Miller et al. (1982) in North Carolina. The prevalences of *A. pimelodi* on hosts from Gull Lake in June 1993 are the highest reported to date. In the present study, *A. pimelodi* primarily attached to the first 2 long gill rakers of arch 1, buccal cavity, and rarely filaments. Gill filaments of centrarchids may not provide a stable attachment for the bulla of *A. pimelodi* and may not be able to support the adult.

The fish community in Gull Lake has changed somewhat over the past 60 yr due to the stocking of species. Bluegill, largemouth bass, yellow perch (*Perca flavescens*), emerald shiner (*Notropis atherinoides*), brown trout (*Salmo trutta*), lake trout (*Salvelinus namaycush*), splake (hybrid, *Salvelinus namaycush* × *Salvelinus fontinalis*) were stocked sporadically between 1930 and 1966 (Dexter, 1991). It is unlikely that *E. centrarchidarum* and *A. pimelodi* were introduced with these fishes since these copepods were not found by Esch and coworkers. The stocking of lake trout, Atlantic salmon (*Salmo salar*), and rainbow trout (*Oncorhynchus mykiss*) into Gull Lake after 1964 (Dexter, 1991) probably did not play a role in the introduction of *E. centrarchidarum* and *A. pimelodi* since they have not been reported from salmonids. Assuming these copepod species were not present earlier, they may have been introduced into Gull Lake around 1974 by the release of infected bass by anglers or by the movement of waterfowl with attached copepods. Perhaps not enough time has passed for *E. centrarchidarum* and *A. pimelodi* to have established host–parasite relationships with bluegill, thus explaining their absence on this fish species in Gull Lake.

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